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Housing Effects on Growth of Young Horses

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TECHNICAL REPORT: HOUSING EFFECTS ON GROWTH OF YOUNG HORSESABSTRACT

Housing effects on growth, feed use and digestion were evaluated in twelve 7 month-old Standardbred colts for 22 week beginning in November. Colts were assigned to one of two groups: warm-housed in a barn heated to 10°C or cold-housed in a barn with no external heat supply. Over the course of the study, the actual mean temperatures of the warm and cold barn were 10.9 and -5.2°C, respectively. Haircoats of cold-housed colts were 1.4- to 2-times heavier than for warm-housed colts in December, February and April but decreased in all colts from fall to spring. Both groups were fed to meet 1989 NRC energy and nutrient requirements for moderate gain (.65 kg/d). Warm-housed colts gained .67 kg/d which was 29% more rapid than gains (.52 kg/d) by cold-housed colts. Skeletal growth, measured by cannon bone circumference, wither and croup height, was minimally affected by cold. Initially, both groups had the same incidence of mild pastern uprightness and epiphysitis. Yet after week 8, the cold-housed colts showed no further abnormality while at the end of the study, four of the 6 warm-housed colts had moderately upright pasterns and of these, three were knuckling at the fetlock. Cold-housed colts digested more fiber and less phosphorus than warm-housed colts. Retention times were similar for both groups. Digestibilities of dietary dry matter, gross energy, phosphorus and fiber declined as the colts got older. Cold-housed colts drank 15% less water when temperatures fell below 0°C. Maintenance energy needs of cold-housed colts were estimated at 34.6 kcal/kg body weight (BW) and for warm-housed colts at 26.3 kcal/kg BW. To sustain constant gain, growing horses need 1.8% more digestible energy per Celsius degree decrease in ambient temperature below 0°C than recommended by 1989 NRC guidelines.

BACKGROUND AND OBJECTIVES

The horse population of Saskatchewan was estimated by Agriculture Canada to be 70,000 in 1981. In western Canada, the horse population is 234,000. Horses are used for recreation or work, functions which depend on normal bone and muscle development. Growth disorders of the skeleton such as osteochondrosis dissecans (OCD) result in substantial production and performance losses in young horses less than two years of age. Various causes have been proposed for these abnormalities including diet, genetics, biomechanical stress, injury, overexercise and hormonal imbalances.

Although ideal growth rates are not known for horses, the 1989 National Research Council (NRC) Nutrient Requirements of Horses bulletin indicates that two growth rates, moderate and rapid, are acceptable. Based on this concept, a moderate and a high energy intake are also considered permissible despite the suspicion that feeding high energy intakes predisposes young horses to OCD. Many factors affect digestible energy (DE) requirements of horses but in the Prairies, ambient temperature and exercise are two important elements.

Winter temperatures in western Canada can drop to -40°C and the average winter temperature is -15°C . Cold weather increases maintenance energy demand for other livestock and this would be expected in horses. Yet, virtually no data is available on the effects of winter on energy demands of horses. Consequently, the 1989 NRC requirements does not modify energy intakes for horses exposed to cold weather. Although horses are successfully reared and worked at or below -20°C , growing horses are assumed to be intolerant of cold temperatures.

Feed efficiency is expected to decrease in growing animals in the cold. Yet, based on anecdotes some horse owners believe that rearing young horses

outdoors benefits their skeletal growth although these horses may be small spring yearlings. The higher maintenance energy demands of cold weather lower the energy available for growth and may alter the adverse impetus of high energy intakes on growth plate development and hence, OCD. This may explain why cold-housed horses show fewer clinical leg abnormalities than those kept in heated barns. However, changes in hormones responsible for bone growth cannot be discounted as the cause of growth disorders.

The objectives of this study were to assess the effects of housing temperature on growth, skeletal development and feed utilization of overwintered, young horses.

EXPERIMENTAL METHODS

Design. A split-plot design was used to examine effects of housing on growth of 7-month old horses over 22 week starting in November. Two colts from each of three sires were assigned to treatments according to a randomized complete block. Treatments were: 1) a control group (warm) housed in a barn set for a mean ambient temperature of 10°C, and 2) a treatment group (cold) kept in an uninsulated barn with no external heat supply. Warm-housed colts were moved into the heated barn a week before the start of the study.

Animals and Housing. Twelve Standardbred colts were used. During adaptation from October to November, the colts were kept in a large paddock with access to brome-alfalfa hay, an unheated barn and a straw-bedded shed. A pelleted diet was fed at the rate of 1.25 kg/100 kg BW daily. The colts were dewormed with an ivermectin paste at 3-month intervals. Horses were kept in concrete-floored box stalls within each barn. The box stall areas were 6.80 m² in the heated barn and 8.1 m² in the unheated barn. Each box-stall had a 2.2

m²-rubber mat fixed to the floor which was used when the colt was lying down. The floor and mat surfaces were also bedded with wood shavings. Each group of horses was put outdoors for exercise in a 200 m² paddock from 10 am to 2 pm.

Maximum and minimum barn temperatures of the previous day were recorded at 8 am daily. These two values were used to calculate average daily temperature. Incandescent lights, spaced at 3.7 or 4.6 meters, were kept lit in each barn for 24 hours. The minimum light intensity of the box stalls in both barns was 10 to 100 lux at a 1-meter height from the rear to the front of the stall during the hours of darkness. During daylight, natural light increased the light intensity. Each colt had an individual water supply.

Experimental Diets. Colts were fed sufficient diet to supply the nutrient needs for moderate growth of 7 month-old horses expected to mature at 500 kg body weight (BW) according to 1989 NRC recommendations. The daily ration for all colts consisted of 75% pelleted diet and 25% coarsely chopped brome hay fed at the rate of 2.21 kg feed/100 kg BW given in two meals daily. Feed intakes were adjusted weekly according to body weight. Feed refusals were weighed and discarded. Refusals were rare but occurred for two horses in the unheated barn which left small amounts of feed (less than 200 g). The pelleted diet was sampled and analyzed at 4-week intervals.

Hair Samples. Clean, dry hair was collected mid-neck about 7 cm below the base of the mane at 3, 11 and 19 weeks after the start of the study. A 5.2 X 7-cm template was constructed from flexible plastic which was placed over the sampling area. A hair clipper with a #30 blade was used to clip all the hair within the template. The hair was collected, air-dried at 25°C, and weighed.

Morphometric Measurements. Weights were taken on an electronic scale which was constructed with a central platform fastened over metal bars

enclosing four load cells. Wooden extensions were built onto both ends of the main platform. Thus, the horse could be advanced onto each platform to obtain fore, total and hind body weight. These measurements were taken weekly. Cannon bone circumference was taken at the mid-point of the left metacarpal bone. These measurements were made at 2-week intervals with a non-elastic tape measure. Withers height was taken at the level of the fifth thoracic vertebra and croup height was measured at the maximal limit of the gluteal muscle using a horizontal level attached to a vertical scale.

Digestion Trials. Total fecal collections of 72-hour duration were made at 3, 11 and 19 weeks after the start of the study. Colts were put in wooden metabolic crates that allowed separate collection of feces and urine. Chromium sesquioxide (Cr_2O_3) pellets were fed in the initial meal of each digestion trial to provide 10 g of Cr_2O_3 /100 kg BW. All colts except two ate their allotted Cr_2O_3 pellets within 15 minutes. The remainder of the meal, pellets and hay, was fed after the Cr_2O_3 pellets were eaten. Horses were watered 3 times daily and the volume was recorded. Total fecal production was measured at 12-hour intervals. Subsamples were taken every 12 hours for nutrient and Cr_2O_3 determinations. Urine volumes were recorded. Pellets and hay were sampled daily and composited.

Feed and Fecal Analyses. Feeds and feces were analyzed for moisture, gross energy (GE), crude protein, acid-detergent fiber (ADF), neutral-detergent fiber (NDF), calcium (Ca) and phosphorus (P) content by 1985 AOAC methods. Chromic oxide content of feeds and feces was determined by a colorimetric technique. The 72-hour cumulative excretion of Cr_2O_3 was evaluated for linear, log and quadratic responses. The highest R^2 ($> .90$) was obtained using a quadratic equation. An 80% feed retention time was calculated

for each group in each period from individual and pooled quadratic equations.

Clinical Evaluation. All horses were regularly evaluated for signs of musculoskeletal abnormality. A scoring system based on a physical examination was used to appraise the musculoskeletal system for signs of physisitis and metacarpophalangeal flexure deformity (contracted tendons). The clinical definitions of epiphysitis (physisitis) and metacarpophalangeal flexure deformity as described by Stashak (1987) were used. Each condition had four possible degrees of involvement: none, mild, moderate or severe. Physisitis was considered mild if visible, but not extensive, metaphyseal flaring was present. Moderate physisitis encompassed the condition with substantial metaphyseal flaring which altered the configuration of the joint area. Severe physisitis was considered to be extensive metaphyseal flaring accompanied by lameness. Flexure deformity was evaluated only at or distal to the metacarpophalangeal joint. Metacarpophalangeal flexure deformities were mild if a very upright pastern was present, moderate if pasterns were very upright and knuckling was evident, and severe if pasterns were very upright, knuckling occurred and if lameness or a gait change was present.

Statistical Analyses. Statistical analyses included analyses of variance and covariance, repeated measures analyses of variance, correlation and regression analyses of balanced and unbalanced data. Initial hair weight (December sample) was used as a covariate to compare February and April samples. Daily gains for weight and height were based on regression analyses of individual data against days on test. The intercept represented the initial measurement and the regression coefficient represented average daily gains (ADG). Average daily gains were also calculated as the difference between initial and final measurements over time. Orthogonal comparisons of period

(age) means compared period 1 versus 2 and period 1 and 2 versus 3 were made for digestibility data. Regression analyses of water intake to ambient temperature was based on daily free water consumption per kg dry matter intake (DMI) versus mean ambient temperature for each day in each digestion trial.

RESULTS AND DISCUSSION

Ambient Temperature. The mean temperatures of the heated and unheated barns over 22 week were $10.9 \pm .66$ and $-5.2 \pm 1.72^{\circ}\text{C}$, respectively. Mean weekly temperatures for each barn and outdoors are shown in Fig. 1. During extremely cold or warm weather, temperatures in the heated barn could not be closely controlled. The range of mean temperatures for the heated barn was 3 to 18°C and for the unheated barn, -26 to 24°C .

Hair Growth. The duration of daylight in mid-December, February and April in Saskatoon is 7.8, 10 and 14 h, respectively. Hair weight of cold-housed horses was 1.46, 1.43 and 2.05-fold heavier than for warm-housed horses in respective periods. Haircoat weights in February and April differed between groups even after covariate adjustment for initial hair weight. The heaviest haircoats for both groups occurred in December which did not coincide with the coldest temperature but corresponded with the shortest daylength.

Hair shedding had started in warm-housed horses at week 11 (mid-February) and substantial hair loss had occurred by week 15 (mid-March). By week 15, only two colts in the unheated barn had shed any hair and this was localized to the face. By week 19 (April), all warm-housed colts had shed their winter hair coats. Cold-housed colts had not completely shed their winter coats by the final week of the study (May).

Hair growth and shedding by horses varies with photoperiod. Both groups

were exposed to similar lighting regimens and light intensities in this study. Thus, the differences in hair coat weight between cold and warm-housed colts show that ambient temperature plus photoperiod regulate hair cover and hair shedding in horses. Warm-housed colts had lighter haircoats in December because they were kept at 10°C for 4 week preceding hair sampling. In cattle, heavier haircoats occur in cold weather because of a reduced rate of shedding rather than stimulated growth. This may have also occurred for these foals.

Morphometrics. The growth of colts reared in unheated and heated barns during the winter are given in Table 4. Total BW of these colts was typical for Standardbred yearlings. Warm-housed colts gained 0.67 kg BW daily which was compatible with the level of nutrient intake. The feeding rate was selected to support an ADG of .65 kg which is considered moderate growth for this class of horse (NRC, 1989). The ADG of warm-housed colts was 28.8% more rapid than obtained for cold-housed colts. Gains in fore and hind BW were directly related to ADG in total BW. In both groups, gains in fore BW were about 60% of total BW gain. Therefore, because total ADG was lower for cold-housed horses, fore body ADG was also lower for these horses. The proportion of fore and hind BW to total BW remained at about 57 and 43%, respectively, for both groups throughout the study. This agrees with values obtained for young Quarter horses and adult draught horses but disagrees with the extreme disproportion in body mass of growing horses reported by some authors.

Gains in chest girth were greater by warm than cold-housed colts (Table 4). Chest girth and total BW were directly related ($r = 0.96$). Total BW (BW, kg) can be predicted from chest girth (X, cm) by the equation, $BW = -476.5 + 5.01 X$ ($R^2 = .90$). This agrees with the association found between total BW (BW, kg) and chest girth (X, cm) for Standardbred foals older than 100 d and

given by the equation, $BW = -459.7 + 4.87 X$ found by others.

Skeletal growth was inferred from measurements of wither and croup height, and cannon bone circumference (Table 4). Although growth rates were slower for cold-housed horses, statistically, housing temperature did not affect skeletal growth. Skeletal growth of these colts was similar to values obtained for young Standardbreds by others. Compared to yearling Quarter horse colts fed a similar energy intake and reared in the same unheated barn, Standardbred colts grew 11 to 14% more rapidly at the wither and croup but 23% more slowly at the cannon. These differences are likely breed related and agree with the different dimensions of adult Standardbreds and Quarter horses.

Clinical Evaluation. Body condition of all colts improved by 1 to 2 scores during the study. At the onset, three colts had mild pastern uprightness and one colt in each group had mild epiphysitis (Table 5). By week 8, all warm-housed horses had mild pastern uprightness, one had epiphysitis and one had boggy hocks. Only three cold-reared colts had mild pastern uprightness at this time. Thereafter, all cold-housed colts were clinically normal except for one colt who was conformationally upright. Four of six warm-housed colts had moderate pastern uprightness and of these, three were knuckling at the fetlock at the end of the study in May.

Nutrient Utilization. Nutrient digestibilities of the diet by colts are given in Table 6. Housing temperature did not affect DM or GE digestibility by weanling colts but these digestibilities declined with maturity of the horses. Dry matter and GE digestibility by warm-housed colts decreased by 10% from 8 to 10 mo of age but remained unchanged at these ages for cold-housed colts. At 12 mo of age, both groups digested DM and GE similarly. Unlike cattle, diet digestibility did not decrease during cold weather for these

young horses fed a hay-grain diet. Factors including processing, diet composition, duration of cold, and age and size of animal modify the extent that cold temperatures affect diet digestion by ruminants. Dry matter digestibility decreases about 0.2% per Celsius degree decrease below 20°C for cattle. Diet composition can alter this response. Cold-exposed ruminants fed high concentrate diets show little or no changes in DM digestibility. The colts were fed a diet containing 55% forage which was coarsely chopped or finely ground (pellet). The absence of a cold effect on diet digestibility by horses may be due to the composition and physical characteristics of the diet.

Lower DM and GE digestibilities were seen in these horses over time. This was associated in part with reduced fiber digestion with age for warm-housed colts. These reductions in fiber digestibility did not occur for cold-housed colts until the final period. At 10 and 12 mo of age, cold-housed horses digested 14 and 9.7% more NDF than warm-housed horses.

Cold exposure resulted in higher digestion of cell wall components by horses. This contrasts data obtained for cattle and sheep but would be a thermodynamically appropriate response to cold. Hypothetically, fiber digestion by horses should generate a higher heat increment than digestion of carbohydrate feeds. An increased retention time would promote increased fiber digestion but this did not occur for cold-exposed colts (Table 6). Rather, a moderate, but insignificant, decline occurred in retention time in both groups of colts from 8 to 12 mo of age. Shorter retention times would reduce ADF and NDF digestion and thus, lower DM and GE digestion. This was seen in both groups of horses at 1 yr of age and may have occurred from changes in activity, hormone secretion or water intake.

The apparent crude protein digestibility of the diet did not change with

age or with housing temperature. In ruminants, effects of cold on protein digestion are conflicting. Some authors have found no changes; others have found reductions in protein utilization. Aging has been reported to lower protein digestion in young horses, but only a small, insignificant decline occurred in protein digestion by colts over time in this study.

True Ca digestibility was estimated using an endogenous fecal Ca excretion of 20 mg Ca/kg BW for horses. Housing temperature did not affect Ca digestion. True P digestibility was estimated using an endogenous fecal P excretion of 10 mg P/kg BW. True P digestibility differed with treatment and age. Warm-housed colts digested 9.2 to 28.4% more P than cold-housed colts. At each successive 8-week interval, dietary P digestion by warm-housed colts decreased by 20% and by 20 to 45% for cold-housed horses. The amount of P absorbed (corrected for endogenous fecal P excretion) per unit of DE intake declined with age in both groups of young horses. Cold-housed horses absorbed .79, .57 and .41 g P/Mcal DE intake at 8, 10 and 12 mo of age, respectively. Concurrent values for warm-housed horses were .85, .65 and .53 g P/Mcal DE intake.

Generally, age has not been considered a critical factor in P metabolism by horses. From 8 to 12 mo of age, P digestion declined in these colts implying that phosphorus demands decrease with maturity in horses. Although reported infrequently for horses and ponies, P utilization declines with age in cattle and pigs. Higher P utilization by horses at younger ages may reflect the intensified tissue and bone metabolism associated with growth. Age changes may elevate endogenous fecal P excretion that may lower P digestibilities in horses with maturity.

Effects of housing temperature on P digestion were confounded by age

effects. Cold-housed horses digested less P than warm-housed horses at all ages. No individual animal discrepancies were found which implies that housing temperature altered P utilization. This was validated by the lower mean blood P concentration of the cold-housed horses (2.26 mmole/liter) compared to the warm-housed colts (2.36 mmole/liter). Reduced P digestion would be disadvantageous to cold-housed animals because this would impair intracellular energy utilization. Phosphorus absorption has been reported to rely on thyroid hormone production. Cold-housed horses had significantly lower triiodothyronine production than warm-housed colts (see elsewhere). Therefore, the lower P digestibility is compatible with this observation.

Retention Time. The 80% feed retention time for cold- and warm-housed colts are given in Table 6. Retention time decreased with age but did not differ between colts kept in the heated or unheated barns. Dry matter, ADF and true P digestibilities were positively related to retention time. Retention times for horses depend on the marker used. Chromic oxide is recovered within 96 hours from horses fed hay or hay-grain diets. Retention times of 45 hours were obtained with polystyrene particles and 23 hours with mordanted chromic oxide. Horses fed complete pelleted and pelleted forage diets had retention times of 28 to 37 hours which is similar to values found here (34-40 hours). Pelleting increases the rate of passage in horses. Therefore, the retention time found here may be shorter than would be obtained for conventional horse diets.

Water Intake and Urine Production. Water intake was computed as free water plus feed water and was directly related to DMI ($r = .80$) (Table 7). Urine production was related ($r = .81$) to water intake. Horses fed this type of diet and housed at 15 to 20°C would be expected to drink 2.0 to 2.5

liters/kg DM. Therefore, water intake by these colts was compatible with the diet used. Free water intake per unit DMI (Y , liters/kg DM) was related ($P < .01$) to ambient temperature (T , °C) according to the equation, $Y = 2.25 + 0.016 T$ ($R^2 = .50$). Thus, water intake decreased 0.71% per degree decrease in temperature below 0°C. In cattle overwintered in the Prairies, water intake decreased 1.75% per degree Celsius below 0°C.

Maintenance Energy Requirement. The maintenance energy requirement of horses (Y) can be predicted by the equation, Y (Mcal DE/d) = $1.4 + .03 BW$. This equation is used in the 1989 NRC handbook to estimate maintenance energy needs for all horses. This equation is based on data collected on idle, mature horses kept in standing stalls in a thermoneutral environment and therefore, does not apply to mature and growing horses kept outdoors in a Saskatchewan winter when temperatures fall below -10°C. Intense cold reduced maintenance energy demands of cold-housed colts substantially as shown by the 20% reduction in gain:feed and gain:DE intake ratios (Table 8). Adult horses use about .408 Mcal DE/500 kg BW or 2.5% more DE for maintenance for each 1°C degree drop below lower critical temperature. Growing horses are estimated to use 3 to 6% more DE for maintenance per Celsius degree below -10°C.

Ambient temperature profoundly affects metabolizable energy (ME) needed for maintenance but does not affect the efficiency by which ME above maintenance is used for growth. If net efficiency of gain is constant regardless of ambient temperature, energetic costs for gain can be assessed using the formula given for a growing horse in the 1989 NRC guidelines. By subtracting the energy used for gain from daily energy intake, the maintenance energy used by each group was derived for each week of the study. Regressing the values for maintenance DE intake against BW, gives the maintenance cost of

rearing growing horses under naturally-occurring cold housing (-5°C) at 34.6 kcal/kg BW. For those horses kept in the warm barn (10°C), maintenance energy needs were 26.3 kcal/kg BW (Table 8).

The equation used in 1989 NRC indicated that the maintenance energy needed by idle, mature horses kept in standing stalls was 21.3 kcal/kg BW. This value was then corrected by 29% for "normal activity". Although the horses used in the present study were confined, they moved freely in their stalls and could exercise voluntarily for 4 hours daily. The maintenance energy needs of warm-housed colts was 14% lower than given by 1989 NRC. By correcting the estimated maintenance requirements by 14%, the maintenance energy needs of the warm-housed colts are derived at 30 kcal/kg BW and for cold-housed horses at 39.4 kcal/kg BW. The increased maintenance energy needed for cold weather agrees with values of 37.8 kcal/kg BW for young horses kept in an unheated barn over winter and 45.7 kcal/kg BW for growing horses kept outdoors in a severely cold winter. Regression of maintenance DE intake (as calculated above) scaled to 100 kg BW on ambient temperature (T , $^{\circ}\text{C}$) resulted in the relationship, Y (DE Mcal/100 kg BW) = $3.2 - .042 T$. Thus, per Celsius degree below 0°C growing horses would need to increase maintenance energy intakes by 4.2%. This value agrees with values for adult, cold-adapted horses at 2.5% more maintenance energy per Celsius degree below their lower critical temperature (-15°C) and is identical to values obtained for sows.

The effect of energy intake on growth disorders of our colts is confounded by changes in hormone levels seen in the warm and cold-housed colts (see elsewhere). The higher incidence of growth-related abnormalities in the warm-housed colts can be speculated to arise from the higher net energy available for productivity. However, the source of metabolic energy may exert

an important influence on hormones which alter bone growth. Warm-housed colts had higher thyroid hormone levels than cold-housed colts throughout the study. Thyroxine and triiodothyronine are important potentiators of growth hormone which in turn causes elongation of the growth plate. The growth plate is involved in epiphysitis and is likely involved in contracted tendons. Thus, the reduction in thyroid hormones as a consequence of cold exposure may act to suppress elongation of the growth plate in cold-housed horses which may temporarily reduce occurrence of both clinical disorders.

This study emphasizes the importance of environmental conditions in equine growth studies. In a prairie climate, growing Standardbred colts overwintered in an unheated barn at a mean ambient temperature of -5°C had weight gains 29% lower than related horses kept in a warm barn (10°C). The reduced weight gains by cold-housed colts were attributed to a higher maintenance energy requirement (39 kcal/kg BW) and may have contributed to the lowered incidence of skeletal or leg abnormalities. The cold-exposed horses gained weight, but their productivity, as measured by ADG, was notably impaired by cold housing despite a nutrient intake which met 1989 NRC guidelines. Based on data from this study, it is recommended that maintenance energy for growing horses should be increased by 4% for each Celsius degree drop in ambient temperature below 0°C . However, this increase in DE should only be applied to the maintenance energy requirement. The daily DE intake needed by weanling horses above 1989 NRC energy values to sustain ADG plus maintenance would be 1.8% per Celsius degree decrease in ambient temperature below 0°C .

CONCLUSIONS AND IMPACT

1. GROWTH. a) Weight gain. Overwintering young horses in unheated shelters (-5°C) and fed at 1989 NRC energy recommendations caused a 29% reduction in average daily gains. The feed:gain ratio for cold-housed colts was 11.25 compared to 8.77 for warm-housed colts. The extra cost of keeping a young horse outdoors in a typical Saskatchewan winter was estimated at \$58 dollars per horse. The heating cost of an insulated barn would be \$1.25 over winter.

b) Skeletal growth. Rates of gain were not statistically different between groups but skeletal growth rates were 2.5 to 7.5% lower for cold-housed horses. At maturity (2-3 yrs of age in horses), these differences are generally unimportant. However, when selling young stock, smaller sizes are a disadvantage.

c) Another implication of the reduced growth of cold-housed weanlings relates to foaling of mares. Mares should be bred to foal early in spring so that foals can be weaned long before the start of cold weather. The older the foal and the more adjusted that foal is to suitable diets at the onset of winter the more likely it will withstand cold weather without growth impairment.

2. SOUNDNESS. The higher incidence of pastern uprightness, indicative of contracted tendons or fetlock flexure deformity, and epiphysitis in warm compared to cold-housed colts was confounded by the changes in hormone levels and energy available for productivity. Because more energy is available for productivity in warm-housed horses, this energy may stimulate hormone

production that contributes to growth disorders. Further proof of this observation is necessary to allow feed management strategies which could minimize occurrence of leg abnormalities.

3. DIGESTION. a) Digestibility of a mixed hay-grain diet by horses was unrelated to housing temperature but decreased with age. The additional feed needed to compensate for the reduction in energy digestibility with age is about 2% per month of age after 6 months.

b) Crude protein digestion does not change with cold weather. Thus, crude protein content in diets of weanling horses does not have to be increased above the recommended concentration of 13% (as fed).

c) Cold and age reduced phosphorus digestibility in young horses. Lowered phosphorus digestibility may be related to reduced thyroid hormone production. Low phosphorus levels reduce heat production and bone quality. The former effect reduces cold tolerance and the latter, bone soundness. In Saskatchewan, it is advisable to increase dietary phosphorus content for weanlings from the recommended concentration of 0.30% to 0.35 or 0.4%.

d) Calcium digestion was unaffected by cold. Thus, calcium content of the diet does not need to be increased above 0.50%. A 20% increase above NRC values is recommended, however, to provide for individual differences in utilization.

4. WATER INTAKE. Water intake was reduced in cold weather. Feeding a more digestible feed is recommended for horses overwintered outdoors to reduce the

amount of water needed to move undigested material through the gut. This reaffirms the advice that snow does not make a reasonable water substitute for horses in winter.

5. ENERGY INTAKE. Young horses reared outdoors in a typical Saskatchewan winter need 1.8% more energy per degree Celsius decrease in temperatures below 0°C than recommended by 1989 NRC guidelines to sustain normal growth. At -30°C, a growing horse will need 50% more of a 63% TDN feed than at 0°C. This is equivalent to feed intake of 3.3% body weight which is near or above maximal gut capacity of a horse. The high feed intake necessitated by cold weather underlines the need to feed highly digestible feeds to growing horses.

Table 1. Ingredient composition (%) of pelleted diet and chromic oxide pellets used in the study

Ingredient	Pelleted diet	Chromic oxide
Alfalfa-brome hay	41.0	41.0
Barley	21.0	21.0
Oats	30.0	21.0
Soybean meal	5.0	5.0
Tallow	1.0	1.0
Sodium monophosphate	.5	.5
Iodized salt	.5	.5
Mineral-vitamin premix ^a	1.0	-
Chromic oxide premix ^b	-	10.0

^a The premix contained (per kg): 0.12% copper, 0.26% zinc, 0.23% manganese, 250,000 IU vitamin A, 27,000 IU vitamin D and 1500 IU vitamin E carried in ground barley.

^b The chromic oxide premix contained (per kg): 0.12% copper, 0.26% zinc, 0.23% manganese, 250,000 IU vitamin A, 27,000 IU vitamin D, 1500 IU vitamin E, 2% molasses, 2% corn oil and 25% chromium sesquioxide in a ground barley carrier.

Table 2. Nutrient composition of hay, pelleted and chromic oxide diet (DM basis)

Nutrient	Brome hay	Pelleted diet	Chromic oxide
Crude protein, %	10.72	15.54	15.26
ADF, %	39.36	22.01	23.36
NDF, %	59.90	41.34	38.81
Calcium, %	.65	.72	.84
Phosphorus, %	.24	.48	.50
GE, Mcal/kg	4.37	4.55	4.43
Cr ₂ O ₃ , %			2.28

Table 3. Effects of acclimation housing temperature ($^{\circ}\text{C}$)^a on hair coat weight (g/cm^2) of growing horses

Wk on Test	Month	Warm			Cold		
		Hair Weight	Temperature Mean	SE	Hair Weight	Temperature Mean	SE
3	December ^b	27.8 ^c	9.4	.5	40.4 ^c	-4.6	1.0
11	February ^b	20.4 ^d	8.5	.2	29.2 ^d	-10.9	.8
19	April ^b	7.7 ^e	10.8	.3	15.8 ^e	-5.9	.9

^a The average mean temperature for 3 wk preceding the December sampling and for 8 wk preceding the February and April sampling.

^b Hair weights of warm and cold-housed colts differ at $P < .01$.

^{c,d,e} Within treatment values among months differ at $P < .01$.

Table 4. Initial and final morphologic measurements and ADG of cold and warm-housed horses

Measurement	Warm			Cold		
	Initial	Final	ADG	Initial	Final	ADG
Total body weight, kg ^a	215.2	318.0	.67	224.8	304.8	.52
Fore body weight, kg ^a	121.7	184.5	.41	127.7	172.7	.29
Hind body weight, kg	92.0	133.6	.27	97.0	130.7	.22
Chest girth, cm ^b	140.1	156.0	.103	139.9	154.1	.092
Wither height, cm	129.7	142.9	.086	128.5	141.4	.083
Croup height, cm	134.2	147.2	.085	132.6	145.2	.082
Cannon bone circumference, cm	16.5	18.6	.014	16.8	18.8	.013

^a ADG between treatments differ at $P < .01$.^b ADG between treatments differ at $P < .05$.

Table 5. Incidence^f and extent[§] of leg abnormalities in cold and warm-housed colts

Weeks on Test	Epiphysitis		Upright Pastern		Knuckling at Fetlock	
	Warm	Cold	Warm	Cold	Warm	Cold
0	1 (1)	1 (2)	3 (1-2)	3 (1-2)	-	-
4	-	1 (1)	3 (1-2)	2 (1-2)	-	-
8	2 (2)	-	6 (1-2)	3 (1-2)	-	-
10	1 (2)	-	5 (2)	2 (1)	-	-
14	1 (1)	-	6 (2)	1 (1)	1 (1)	-
18	2 (1-2)	-	6 (1-2)	1 (1)	2 (2)	-
22	-	-	5 (1-2)	1 (1)	3 (2)	-

^f The values given in the table refer to numbers of animals out of six colts affected and in brackets the degree of abnormality.

[§] The value of 1 indicates mild and 2 indicates moderate involvement as described in the text.

Table 6. Dietary nutrient digestibilities (%) and 80% retention time (h) by warm-housed or cold-housed colts.

Item	Period Group Age	1		2		3		SE
		Warm 8 mo	Cold 8 mo	Warm 10 mo	Cold 10 mo	Warm 12 mo	Cold 12 mo	
Dry matter ^a		64.8	63.3	60.0	62.7	56.9	57.9	.50
Gross energy ^a		64.1	61.7	58.2	61.2	56.9	57.4	.50
Crude protein		77.7	77.8	75.9	76.6	74.0	73.0	.40
ADF ^b de		25.3	23.5	20.0	29.6	12.8	18.8	.79
ND ^b de		48.3	45.2	40.1	45.5	36.0	39.5	1.07
Ca ^a		67.8	68.7	72.9	73.4	69.5	68.0	.80
pAbod		52.2	46.9	42.8	39.2	34.8	27.1	1.50
Retention time		40.5	40.2	38.9	37.2	36.9	34.1	.93

^a Represents true Ca or P digestibility based on correction for endogenous fecal Ca excretion of 20 mg per kg BW and for P of 10 mg/kg BW.

^b Within comparison, values for warm and cold-housed horses differ at $P < .05$.

^c Within comparison, values for period 1 and 2 differ at $P < .05$.

^d Within comparison, values for period 3 and those of period 1 and 2 differ at $P < .05$.

^e A treatment X period interaction was significant at $P < .05$.

Table 7. Effects of housing temperature on daily water intake and urine production of warm and cold-housed colts

Item	Period		1				2				3				SE
	Group	Age	Warm		Cold		Warm		Cold		Warm		Cold		
			8 mo	8 mo	10 mo	10 mo	10 mo	10 mo	12 mo	12 mo	12 mo	12 mo			
Temperature, °C ^{ab}			9.4	-8.4	8.2	-16.9	15.5	6.2						.82	
DMI, kg ^c			5.00	5.19	5.73	5.72	6.02	5.89						.10	
Free water intake, liters ^{ab}			12.44	11.96	13.78	11.92	16.25	15.29						.38	
Water intake, liters/kg DMI ^{abc}			2.49	2.30	2.40	2.08	2.70	2.60						.05	
Urine produced, liters ^{ab}			4.14	4.00	6.27	5.17	7.36	5.77						.25	
Fecal water, liters ^{bc}			4.54	5.03	5.45	5.04	6.68	6.34						.18	

^a Values for warm-housed colts differ ($P < .05$) to those for cold-housed colts.

^b A period effect was present ($P < .05$).

^c Water intake includes free water plus feed water.

Table 8. Average weights, intakes and efficiencies over 22-wk for colts reared in a warm or cold barn during winter in a prairie climate

Item	Warm	Cold	SE
Mean barn temperature, °C	10.9	-5.2	1.55
ADG, kg/d ^a	.67	.52	.03
DMI, kg/d	5.88	5.85	.03
DE intake, Mcal/d	15.83	15.76	.06
Gain to feed, g/kg DM ^a	113.3	90.5	4.71
Gain to DE, g/Mcal DE ^a	42.2	33.5	1.73
Maintenance requirement kcal/kg W ^{ab}	34.6	26.3	.18

^a Within comparison, treatments differed at $P < .05$.

^b Assumes efficiency of gain was unaffected by ambient temperature.

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